

DELPHACODES CAMPESTRIS (VAN DUZEE) AND *D. LUTULENTA* (VAN DUZEE) (HEMIPTERA: FULGOROMORPHA: DELPHACIDAE): ASSOCIATION WITH COMMON HAIRGRASS, *DESCHAMPSIA FLEXUOSA* (POACEAE), AND NOTES ON HABITATS, SEASONALITY, AND TAXONOMY

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Abstract.—Common hairgrass, *Deschampsia flexuosa* (L.) Trin. (Poaceae: Pooideae), is recorded as a new host for the widespread Nearctic planthoppers *Delphacodes campestris* (Van Duzee) and *D. lutulenta* (Van Duzee). We found *D. lutulenta* in Maryland, New York, Pennsylvania, Virginia, and West Virginia at 10 sites, ranging from disturbed areas such as roadside slopes to more natural communities such as a mid-Appalachian shale barren and high-elevation rock outcrops. In North Carolina, South Carolina, and Tennessee, the delphacid associated with common hairgrass was *D. campestris*, which we collected at six sites in the southern Appalachians and upper Piedmont; it was found in grassy balds, on a high-elevation granitic dome and high-elevation granitic outcrop, and on a low-elevation granitic dome. In addition to characterizing their habitats, we give notes on the seasonality and taxonomy of both planthoppers.

Key Words: Insecta, common hairgrass, grass feeding, southern Appalachians, grassy balds, granitic outcrops, shale barrens

Delphacodes campestris (Van Duzee) and *D. lutulenta* (Van Duzee) are common, widely distributed Nearctic planthoppers generally found in meadows and pastures (e.g., Spooner 1920; Osborn and Drake 1922; Osborn 1938, 1939). Unlike most North American Delphacidae, including the majority of other *Delphacodes* species (Ballou et al. 1987, Calvert et al. 1987), their host plants (grasses; Poaceae) are reasonably well known, and both species have been studied in the field and laboratory (e.g., Giri and Freytag 1983a, b; Wilson et al. 1993). Here we give new state records; record common hairgrass, *Deschampsia flexuosa* (L.) Trin. (Poaceae: Pooideae), as a new host; and provide taxonomic and biological notes.

METHODS

Common hairgrass, *D. flexuosa*, was sampled (by AGW) for planthoppers in Maryland, New York, Pennsylvania, Virginia, and West Virginia from late July to early August 2002, and in North Carolina, South Carolina, and Tennessee from 2002 to 2005. Plants were tapped over a white enamel tray with an ax handle, and a plastic vial was used to collect dislodged nymphs and adults from the tray. Notes on seasonality are based mainly on collections and observations of *D. campestris* at irregular intervals at Glassy Mountain, Pickens County, South Carolina, from March 2002 to March 2005. Nymphal instars, when sorted in the field, are indicated by roman

numerals in the Seasonality and Material examined sections; otherwise, nymphs are referred to generally as early, mid-, or late instars. Brachypterous and macropterous adults are denoted by "b" and "m," respectively; asterisks indicate new state records. Records of *D. campestris* from Roan Mountain in Carter County, Tennessee, are listed under Mitchell County, North Carolina. Determinations of the *Delphacodes* species were made by CRB, and voucher specimens were deposited in the University of Delaware Insect Reference Collection, Newark, Delaware, and the Clemson University Arthropod Collection, Clemson, South Carolina.

We compiled distribution records from the literature, citing the first reference that lists a particular state. Older records, especially those prior to R. H. Beamer's work, may be suspect. For each species, we also give a critical synonymy and taxonomic notes. The list of synonymy includes the original combination and synonyms since publication of Metcalf's (1943) catalog of Delphacidae, which includes an exhaustive synonymy up to 1940. Morphological terminology follows Asche (1985).

Delphacodes Fieber

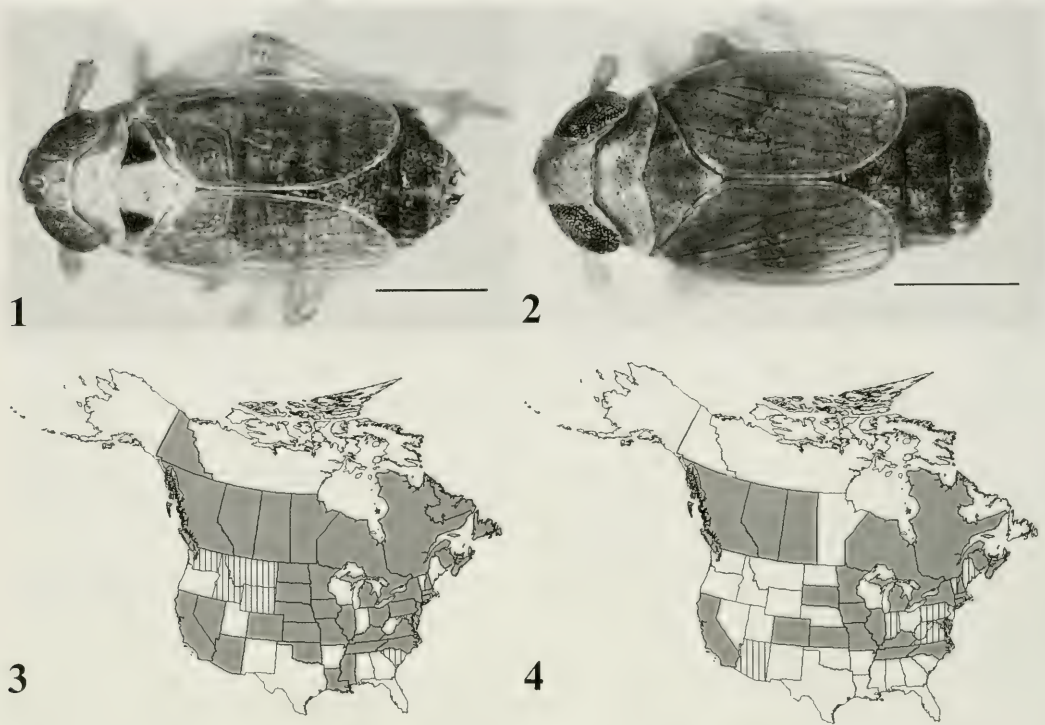
As currently defined, the genus *Delphacodes* Fieber, 1866 (Delphacinae: Delphacini; type species *Delphax (Delphacodes) mulsanti* Fieber, 1866), consists of 10 Old World species (Wagner 1963, Asche and Remane 1983, Asche 1985), with all New World *Delphacodes* in *incertae sedis*. Approximately 95 species of *Delphacodes* are found in North America, but comprehensive keys to species are lacking. *Delphacodes* species can be definitively identified only by features of the male genitalia. *Delphacodes campestris* and *D. lutulenta* (Figs. 1–2) are similar in size and shape of the head; size, shape, and dentition of the hind tibial spur; and in lacking processes on segment 10, and the posteriorly projecting diaphragm armature. They are most easily recognized using the works by DuBose

(1960) or Wilson and McPherson (1980a). They often can be distinguished in the field by color (*D. campestris* is paler), but examination of male genitalia is needed to confirm their identity. *Delphacodes campestris* has broader parameres in caudal view and teeth on the aedeagus (lacking in *D. lutulenta*). *Delphacodes campestris* and *D. lutulenta* are similar in having no processes on segment 10 and the armature of the genital diaphragm posteriorly projecting (Figs. 5–10). Both species fall within the same clade among the more advanced Delphacini in preliminary phylogenetic analyses using combined molecular and morphological data (Cryan and Bartlett, unpublished).

Delphacodes campestris (Van Duzee) (Figs. 1, 3, 5–7)

Liburnia campestris Van Duzee 1897: 254.
Liburnia osborni Van Duzee 1897: 250,
synonymy by Oman 1947: 210.
Liburnia unda Metcalf 1923: 207, synonymy
by Metcalf 1949: 56.

Van Duzee (1897) described *D. campestris* from Michigan, Mississippi, New Hampshire, New York, and Ontario. *Liburnia osborni* (Van Duzee 1897) and *L. unda* (Metcalf 1923), considered synonyms of *D. campestris*, were described from Iowa, Michigan, New Jersey, and New York, and from North Carolina, respectively. *Delphacodes campestris* also is known from Arizona, California, Colorado, Connecticut, District of Columbia, Kansas, Louisiana, Massachusetts, Nevada, Pennsylvania (Metcalf 1943); Illinois, Minnesota, Missouri, Nebraska, Ohio (DuBose 1960); South Dakota (Stoner and Gustin 1980); Kentucky (Giri and Freytag 1983a); and North Dakota, Oklahoma, Tennessee, and Virginia (Wilson 1992). Canadian records are available for Alberta, Yukon (Wilson 1992); British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Sas-



Figs. 1-4. Adult male habitus and distribution. 1, 3, *Delphacodes campestris*. 2, 4, *Delphacodes lutulenta*. On maps, shaded states are published records; hatched states are new records. *Delphacodes lutulenta* also is known from Puerto Rico.

katchewan (Maw et al. 2000). In addition to these previously published records and those reported herein, CRB has observed specimens in collections from Delaware, Idaho, Maryland, Montana, Washington, and Wyoming (Fig. 3).

Data on the bionomics of *D. campestris* include the collection of nymphs and adults in Nebraska on eight irrigated, cool-season grasses of the subfamily Pooideae. Densities varied seasonally on different hosts and were highest on intermediate wheatgrass (*Thinopyrum intermedium* (Host) Barks-worth and D.R. Dewey). The delphacid produced two generations in the study plots; nymphs of a partial third generation overwintered (Whitmore et al. 1981). In Kentucky, nymphs and adults were collected from plots of mixed grasses (chloridoid, panicoid, and pooid species) from June to November. The incidence of macroptery

was 31.3% in 1980 and 42.5% in 1981 (Giri et al. 1985). When tested on seven grasses in the laboratory, *D. campestris* colonized four species: Johnson grass (*Sorghum halepense* (L.) Pers.), oats (*Avena sativa* L.), tall fescue (*Lolium arundinaceum* (Schreb.) S. J. Darbyshire), and wheat (*Triticum aestivum* L.) (Giri and Freytag 1983a). Wilson et al. (1993) collected adults from a tall-grass prairie in Missouri. In the laboratory, using a colony initiated from eggs deposited by females collected in South Dakota, *D. campestris* reproduced successfully (oviposition plus nymphal development) on 39 native and introduced C₃ and C₄ grasses of several subfamilies. Cereals such as barley (*Hordeum vulgare* L.), oats, rye (*Secale cereale* L.), and wheat allowed a rapid buildup of populations for maintaining stock colonies. In the laboratory at 25°C, total development time (egg to adult) av-

eraged 31 days for males and 35 days for females. Longevity of mated females ranged from 18 to 55 days; fecundity ranged from 213 to 919 eggs (Stoner and Gustin 1980).

Habitats.—In the southern Appalachians of North Carolina (and in Tennessee on Roan Mountain), we found *D. campestris* on common hairgrass in grassy balds on Black Balsam Knob (ca. 1,735 m) and Roan Mountain (ca. 1,685 m); in a high-elevation granitic outcrop (ca. 1,125 m) in Alleghany County; and in a red oak (*Quercus rubra* L.) forest on Whiteside Mountain (ca. 1,490 m), a high-elevation granitic dome. We found the planthopper in South Carolina in the Mountains (Blue Ridge) ecoregion near the overlook (ca. 975 m) at Caesars Head State Park, a high-elevation granitic outcrop, and in the Piedmont ecoregion on Glassy Mountain (ca. 515 m), a monadnock that is a low-elevation granitic dome.

Seasonality.—On Glassy Mountain in South Carolina, *D. campestris* overwintered mainly as late instars. Nymphs were more numerous than newly developed adults on 10 March 2002, but by 16 March only adults (brachypters) were found. In 2003, a brachypterous male was observed with late instars on 9 March. In 2005, the first 20 individuals observed during sampling on 25 March included 18 brachypterous adults (4 ♂, 14 ♀) and two fifth instars. Nymphs (instars I–V) of a new generation were present with smaller numbers of brachypters on 12 May 2002; late instars and brachypterous and macropterous adults were observed on 29 May. The planthopper was more difficult to find in mid- to late June 2002, with late instars and adults present on 15 June and only adults on 22 June. Nymphs (early to late instars) of a second generation were found on 8 July when only one adult was observed; a late-July collection consisted of small numbers (<10) of early and late instars and a brachypterous female. Sampling on 17–18 August did not yield nymphs or adults. On 21 August, fewer than five early instars and a brachypterous female were ob-

served on Whiteside Mountain in western North Carolina.

Taxonomic notes.—*Delphacodes campestris* (Fig. 1) is light tan, sometimes with an orangish abdomen, with dark brown spots on the front coxae and lateral compartments of the mesonotum. *Delphacodes campestris* is most similar morphologically to *D. atralabris* Beamer, 1948a, which is smaller and lacks the dark markings on the mesonotum, and *D. lutea* Beamer, 1946 and *D. penelutea* Beamer, 1948b, which lack dark markings. All four species differ in the shape of the parameres and aedeagus but have similarly shaped diaphragm armatures and lack processes on segment 10 (Beamer 1946, 1947, 1948a, b; Wilson & McPherson 1980a).

Material examined.—NORTH CAROLINA: Alleghany Co., ca. 10 km E of Laurel Springs, 16 June 2002, 3b ♂, 3b ♀; 4 Aug. 2002, 5b ♂, 5b ♀; Haywood Co., Black Balsam Knob, 18 July 2002, 14 b ♂, 3 m ♂, 16b ♀, 7 m ♀; 29 Sept. 2002, 3b ♂; Jackson Co., Whiteside Mountain, ca. 6 km NE of Highlands, 21 Aug. 2002, 1b ♀; Mitchell Co., Roan Mountain, Carvers Gap, 27 Oct. 2002, 1 m ♂, 1b ♀, late instars; 31 Aug. 2003, adults, nymphs; 7 Nov. 2004, 3b ♂, 1 m ♂, III–V. *SOUTH CAROLINA: Greenville Co., overlook, Caesars Head State Park, 6 Nov. 2004, IV–V; Pickens Co., Glassy Mountain, 4.2 km NE of Pickens, 10 Mar. 2002, brachypters, III–V; 16 Mar. 2002, brachypters; 12 May 2002, brachypters, macropters, I–V; 29 May 2002, brachypters, macropters, late instars; 15 June 2002, 3b ♂, 2 b ♀, 1 m ♀, III–V; 22 June 2002, 2b ♂, 2 m ♂, 2b ♀, 2 m ♀; 8 July 2002, 1b ♂, early-late instars; 27 July 2002, 1b ♀, 2 early, 3 late instars; 9 Mar. 2003, 1b ♂, 9 mid-late instars; 13 Apr. 2003, 1b ♂; 6 Nov. 2004, III–V; 25 Mar. 2005, 4b ♂, 14b ♀, 2V. TENNESSEE: See NORTH CAROLINA: Mitchell Co.

Delphacodes lutulenta (Van Duzee)
(Figs. 2, 4, 8–10)

Liburnia lutulenta Van Duzee 1897: 252.



Figs. 5–10. Male genitalia. 5–7, *Delphacodes campestris*. 8–10, *D. lutulenta*. 5, 8 = pygofer, caudal view. 6, 9 = pygofer, lateral view. 7, 10 = aedeagal complex, lateral view. Scale bar = 0.2 mm.

Described from New York (Van Duzee 1897), *D. lutulenta* has been recorded from 15 additional states: California, Colorado, Connecticut, Kansas, Massachusetts, Minnesota, New Hampshire, Ohio (Metcalf 1943); North Carolina, South Dakota (DuBose 1960); Illinois (Wilson and McPherson 1980b); Kentucky (Sperka and Freytag 1975); Maryland (Bean and Denno 1980; the study site was not listed but was in Maryland [R. A. Bean, personal communication]); Missouri (Wilson et al. 1993); and Tennessee (Bartlett and Bowman 2003). Canadian records include Alberta, British Columbia, Nova Scotia, Ontario, Quebec, and Saskatchewan (Maw et

al. 2000). It also is known from Puerto Rico (Osborn 1929, 1935). In addition to these records, and those reported herein, CRB has observed specimens in collections from Arizona, Delaware, Indiana, Maine, and Vermont (Fig. 4).

In Kentucky, *D. lutulenta* was trivoltine and the most abundant delphacid in mixed-grass pastures (Giri and Freytag 1983a, Giri et al. 1985). Under controlled conditions, the planthopper developed on 13 grasses in the subfamilies Panicoideae and Pooideae; wheat was the preferred host. At 26°C, development times for males (33.4 days) and females (34.2 days) were not statistically different. Mean fecundity was 430.5 eggs,

and longevity was 27 days for males and 34 days for females (Giri and Freytag 1983b). Other host grasses are *Ischaemum muticum* L. (as *Andropogon repens* (Roxb.) Steud.) and *Puccinellia nuttalliana* (Schultes) A. Hitchc. (Wilson et al. 1994).

Habitats.—We collected *D. lutulenta* in New York in a pitch pine-oak-heath rocky summit of the northern Shawangunk Mountains (ca. 365 m), in oak-hickory and mixed deciduous forests in Pennsylvania, a shale barren in Maryland, and at the edge of woodlands and along shaded roadside banks in Maryland and West Virginia. The Virginia collections were from high-elevation (ca. 1230 m) rock outcrops.

Seasonality.—Collections were nearly limited to late July 2002. Late instars were found with brachypters at all sites in Maryland, Pennsylvania, Virginia, and West Virginia. No macropters were observed during 21–23 July. An early-August collection in Virginia included an early instar with brachypterous adults.

Taxonomic notes.—*Delphacodes lutulenta* (Fig. 2) is brownish tan, usually with a darker abdomen. It is most similar morphologically to *D. lutulentoides* Beamer, 1948a and *D. perusta* Beamer, 1947. *Delphacodes lutulentoides* differs mainly in having teeth on the aedeagus and more spatulate parameres (Beamer 1948a). *Delphacodes perusta* has short processes on segment 10, each with a mediobasal tooth, and parameres that are broad and laterally directed basally, and that narrow and are medially directed beyond midlength (Beamer 1947). *Delphacodes perusta* was found in this study on *Danthonia sericea* Nuttall (Poaceae) in Pickens Co., South Carolina.

Material examined.—MARYLAND: Washington Co., Rt. 144, 5.5 km W of Hancock, 22 July 2002, 4b ♂, 7b ♀, 2V; Woodmont Rd. 2.5 km S of Exline, 22 July 2002, 2 b ♂, 3b ♀, IV–V; Boy Scout shale barren, NE of Little Orleans, 22 July 2002, 12b ♂, 10b ♀, III–V. NEW YORK: Ulster Co., Mohonk Preserve, Bonticou Crag, 4 Sept. 2002, 5b ♂, 2b ♀. *PENNSYLVANIA:

Franklin Co., Warren Township SW of Sylvan, lower slope Keefer Mountain, N of T301 (Red Rock Rd.), 23 July 2002, 2b ♂, 5b ♀, IV–V; Franklin Co., Warren Township, SW of Sylvan, N of Rt. 456 E of jet. T301 (Red Rock Rd.), 23 July 2002, 8b ♂, 15b ♀, IV–V. *VIRGINIA: Bath Co., Rt. 703, Bald Knob, 3.5 km N of Alleghany Co. line, 3 Aug. 2002, 16b ♂, 3b ♀, 1 early instar; Madison Co., Hawksbill Mountain, 21 July 2002, 9b ♂, 9b ♀, IV–V. *WEST VIRGINIA: Morgan Co., Nebo Rd. E of Rt. 9, ca. 9 km S of Great Cacapon, 22 July 2002, 1b ♂, 2b ♀, late instars; Rt. 9, ca. 3 km N of Largent, 22 July 2002, 2b ♂, IV.

DISCUSSION

Delphacodes campestris and *D. lutulenta* are multivoltine grass feeders (Whitmore et al. 1981, Giri et al. 1985). Under controlled conditions in the greenhouse or laboratory, they can reproduce on many of the same hosts, mainly pooid grasses (Stoner and Gustine 1980; Whitmore et al. 1981; Giri and Freytag 1983a, b). The planthoppers have a similar distribution—essentially transcontinental in Canada (Maw et al. 2000), south to the southeastern states, and west to California (Metcalf 1943; DuBose 1960)—and sometimes co-occur (e.g., Spooner 1920, Osborn and Drake 1922, Giri et al. 1985, Wilson et al. 1993). They also both serve as hosts of the dryinid parasitoid *Dicondylus americanus* (Perkins) (Giri et al. 1985, Giri and Freytag 1988).

Both planthopper species might also be grass generalists (*sensu* Whitcomb et al. 1988), although information on their host-plant range is based mainly on the screening of cultivated grasses in the greenhouse or laboratory, or on studies of grasses in single- or mixed-species field plots. Little is known about the wild grasses that serve as hosts of these delphacids.

In the eastern United States, we found nymphs and adults of *D. campestris* and *D. lutulenta* on common hairgrass. Several Palearctic delphacids are known from this Holarctic grass (e.g., Holzinger et al. 2003,

Nickel 2003), but *Deschampsia flexuosa* apparently is a new host for Nearctic plant-hoppers. *Delphacodes campestris* and *D. lutulenta*, though found on common hairgrass from New York to South Carolina, were never syntopic. *Delphacodes lutulenta* was associated with common hairgrass at more northern sites (New York to northern Virginia), whereas *D. campestris* was found on the grass at southern sites (North Carolina, South Carolina, and southern Tennessee). The north-south disparity in host use was not based solely on differences in elevation; *D. lutulenta* in Virginia was found at higher elevations than was *D. campestris* at certain sites in North Carolina, South Carolina, and Tennessee. The ecological factors influencing the planthoppers' use of common hairgrass in different geographic areas are unknown and might be an artifact of our limited number of sample sites. Van Duzee (1897) noted that *D. campestris* is numerous in dry pastures, whereas *D. lutulenta* is found on grass in damp situations.

Phytophagous insects typically feed on a particular host plant in only part of the plant's range (e.g., Strong et al. 1984), as in Delphacidae associated with the cordgrass *Spartina patens* (Ait.) Muhl. in eastern North America (Denno et al. 1981). Certain European delphacids (assuming cryptic or sibling species are not involved) show geographic variation in host use, some species having reduced diet breadth in northern portions of their range (Nickel 2003). An interpretation of the observed patterns of host use in *D. campestris* and *D. lutulenta* must await experimental field and laboratory studies, and perhaps information on the genetic basis of their host-plant adaptation. Either or both might represent a complex of sibling species.

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